FLOOD INSURANCE STUDY

TOWN OF WEST BOYLSTON, MASSACHUSETTS
WORCESTER COUNTY

REVISED

AUGUST 2, 1990

Federal Emergency Management Agency

COMMUNITY NUMBER · 250345

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program (NFIP) have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this FIS may be revised and republished at any time. In addition, part of this FIS may be revised by the Letter of Map Revision (LOMR) process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current FIS components.

Initial Flood Insurance Study Effective Date: January 2, 1981
(Flood Insurance Rate Map effective July 2, 1981)

Flood Insurance Study Revised: August ?, 1990

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
	1.1 Purpose of Study	1
	1.2 Authority and Acknowledgments	1
	1.3 Coordination	1
2.0	AREA STUDIED	2
	2.1 Scope of Study	2
	2.2 Community Description	2
	2.3 Principal Flood Problems	4
	2.4 Flood Protection Measures	4
3.0	ENGINEERING METHODS	5
	3.1 Hydrologic Analyses	6
	3.2 Hydraulic Analyses	7
4.0	FLOODPLAIN MANAGEMENT APPLICATIONS	8
	4.1 Floodplain Boundaries	8
	4.2 Floodways	9
5.0	INSURANCE APPLICATIONS	13
6.0	FLOOD INSURANCE RATE MAP	15
7.0	OTHER STUDIES	15
8.0	LOCATION OF DATA	15
9.0	BIBLIOGRAPHY AND REFERENCES	15

TABLE OF CONTENTS - continued

Page

FIGURES

Figure 1 - Vicinity Map 3

Figure 2 - Floodway Schematic 13

TABLES

Table 1 - Summary of Discharges 6,7

Table 2 - Floodway Data 10 - 12

EXHIBITS

Exhibit 1 - Flood Profiles
Gates Brook Panels 01P-06P
Waushacum Brook Panel 07P
Tributary to Waushacum Brook Panels 08P-09P

Exhibit 2 - Flood Insurance Rate Map Index and Street Index
Flood Insurance Rate Map

Exhibit 3 - Elevation Reference Marks

FLOOD INSURANCE STUDY
TOWN OF WEST BOYLSTON, WORCESTER COUNTY, MASSACHUSETTS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study revises and updates a previous Flood Insurance Study/Flood Insurance Rate Map for the Town of West Boylston, Worcester County, Massachusetts. This information will be used by the Town of West Boylston to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP). The information will also be used by local and regional planners to further promote sound land use and floodplain development.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the state (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses in this study represent a revision of the original analyses prepared by Schoenfeld Associates, Inc., for the Federal Emergency Management Agency (FEMA), under Contract No. H-4794. The hydrologic and hydraulic analyses in this revision were prepared by the New England District of the U. S. Army Corps of Engineers (COE), under Inter-Agency Agreement No. EMW-84-E-1506, Project No. 1, Amendment No. 26. This study was completed in May 1988.

1.3 Coordination

On November 16, 1984, an initial Consultation and Coordination Officer's (CCO) meeting was held with representatives of FEMA, the COE (the study contractor), and the town to determine the streams to be studied by detailed methods.

On September 26, 1989, a final CCO meeting was held with representatives of FEMA, the study contractor, and the town to review the results of the study.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the Town of West Boylston, Worcester County, Massachusetts. The area of study is shown on the Vicinity Map (Figure 1).

The following streams were studied by detailed methods: Gates Brook, from a point approximately 120 feet downstream of the Boston and Maine Railroad to a point approximately 80 feet upstream of Pierce Street; Waushacum Brook, from a point approximately 150 feet upstream of its confluence with Wachusett Reservoir to a point approximately 300 feet upstream of State Route 12; and Tributary to Waushacum Brook, from its confluence with Waushacum Brook to a point approximately 50 feet downstream of Fairbanks Road. The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction through May 1993.

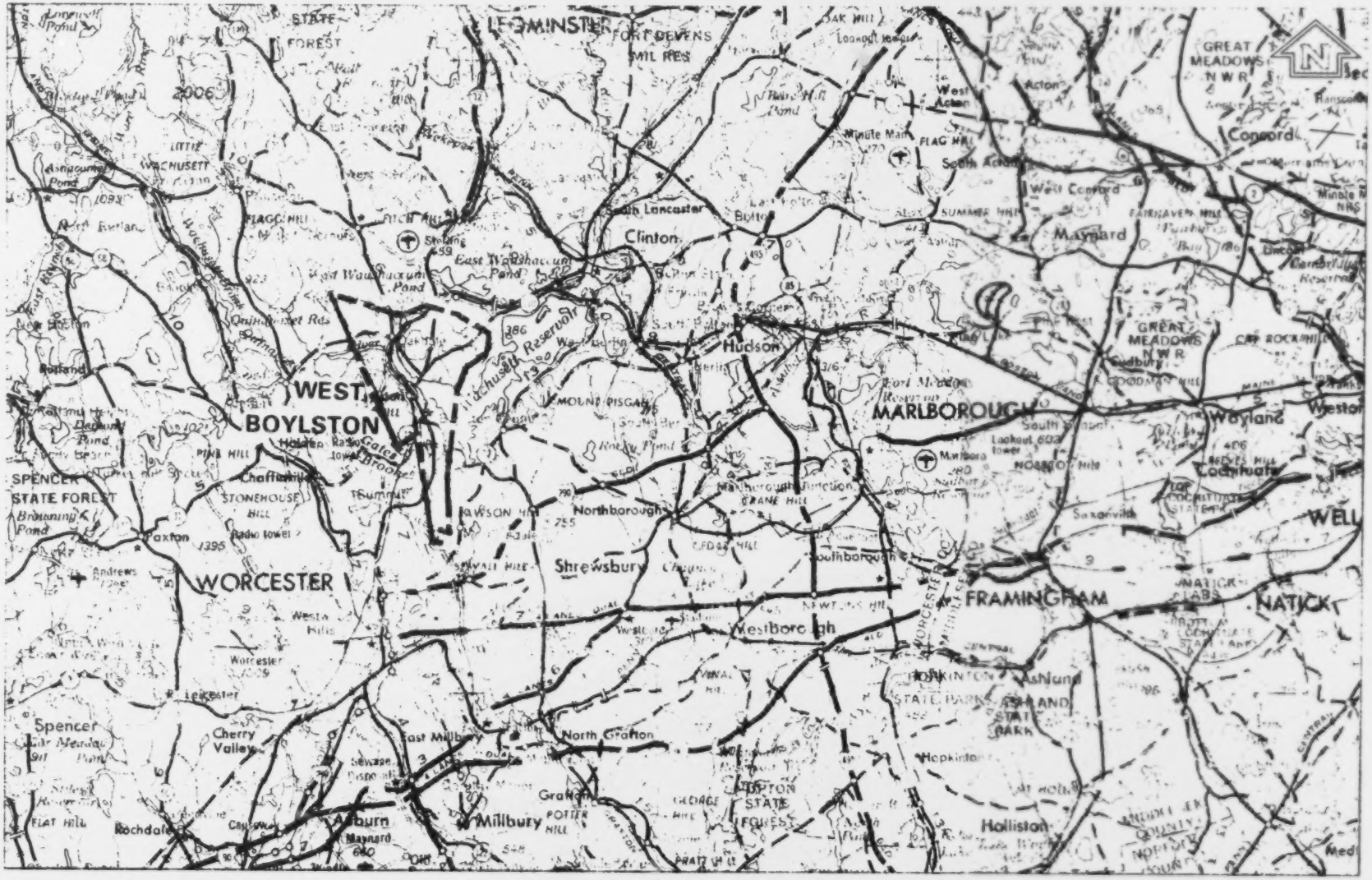
The following flooding sources were studied by approximate methods: Wachusett Reservoir, the Quinapoxet River, Stillwater Basin, Scarletts Brook, Lamson Brook, Thomas Basin, Maiden Brook, Lily Ponds, several unnamed streams, and portions of Gates Brook. Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA and the Town of West Boylston.

2.2 Community Description

The Town of West Boylston is located in the central portion of Worcester County, in central Massachusetts. It is bordered by the Town of Boylston to the southeast, the Town of Holden to the southwest, the Town of Princeton to the northwest, and the Town of Sterling to the northeast. The town covers an area of 12.7 square miles. The population of the town decreased from 6,204 in 1980 to 6,101 in 1985 (References 1 and 2).

Most of the development within the town has been to the south of Wachusett Reservoir, with only two distinct sub-areas of development; one of these is located to the north and one to the west of Thomas Basin. In the southern half of the town, development has paralleled State Route 12 (Reference 3). Approximately 56 percent of the town has been developed; the remaining land is either vacant or wooded. Development within the floodplains is limited, consisting of a few single-family residences and private businesses.

The southwest corner of the town drains into Lake Quinsigamond. The remaining portion of the town drains into the reservoir, which is capable of discharging into the Merrimack River (Reference 4).


WEST BOYLSTON
WORCESTER
Clinton
Hudson
MARLBOROUGH
Northborough
Shrewsbury
Westborough
FRAMINGHAM
NATICK
Auburn
Millbury
Holliston
Spencer
Leicester
Rochdale
Maynard
Concord
Acton
Wayland
North Grafton
Hopkinton
SPENCER STATE FOREST
GREAT MEADOWS N.W.R.
LEOMINSTER
STATE FOREST
FORT DEVENS MIL RES
Wachusett Reservoir
Cherry Valley
Grafton
Boylston
Paxton
Holden
Sudbury
Lincoln
Weston
Natick Labs
Framingham
Southborough
Westborough
Worcester
Auburn
Millbury
Holliston
Hopkinton
Clinton
Hudson
Marlborough
Northborough
Shrewsbury
Maynard
Concord
Acton
Wayland
Sudbury
Lincoln
Weston
Natick
Framingham
Westborough
South

Gates Brook originates in the swamplands just east of Prospect Street, and flows east to West Boylston Street. It then turns to the north after crossing West Boylston Street and discharges into the Wachusett Reservoir.

Waushacum Brook originates at East and West Waushacum Ponds in Sterling. The brook has a drainage area of 8.3 square miles at its confluence with Wachusett Reservoir. The average slope of the brook is 19 feet per mile.

Tributary to Waushacum Brook originates in the northeast portion of West Boylston. It has a drainage area of 1.7 square miles at its confluence with Waushacum Brook. The average slope of Tributary to Waushacum Brook is 55 feet per mile.

The climate of the town is temperate, with normal summer and winter temperatures ranging from 70.9 degrees Fahrenheit (^{o}F) to 26.2^{o}F, respectively. Average annual precipitation is 47 inches (Reference 5). This precipitation is fairly uniformly distributed throughout the year (Reference 6). The annual average runoff is approximately 22 inches (Reference 7). Annual snowfall averages 50 to 60 inches. Topography has a marked influence on snowfall, causing large variations in short distances.

The topography is hilly, with elevations up to 800 feet. The Metropolitan District Commission operates the Wachusett Reservoir, which is located in a large valley in the northeastern portion of the town. The valley floors have sandy loam to loamy sand soils, with the soil becoming more stony on the hill slopes (Reference 5).

2.3 Principal Flood Problems

Major storms have occurred in nearly every month of the year. The northeaster, one of the most serious types of storms, generates very strong winds and heavy rain or snow. In the winter, northeasters produce the heaviest snowfalls; during the fall and spring, they are one of the most frequent causes of flooding. Some of the most severe floods have been those associated with hurricanes or tropical storms, which usually occur in late summer or early fall. The most significant flood-producing storms of this century were the hurricanes of September 1938, August 1955, and September 1960; and the non-hurricane storms of November 1927, March 1936, November 1953, March 1963, and March 1968 (Reference 6).

2.4 Flood Protection Measures

The Town of West Boylston is a participant in the Regular Phase of the NFIP, and has incorporated into its zoning laws a set of floodplain management regulations to help minimize future flood damages and related hazards.

There are no flood protection structures located along Gates Brook. Nonstructural measures of flood protection are being used to prevent future flood damage. The Wetlands Protection Act requires that a permit be obtained in order to remove, fill, dredge, or alter wetlands and gives the responsibility of issuing these permits to town conservation commissions. A permit is required whenever the town determines that an area "is significant to public or private water supply, to the ground water supply, to flood control, to storm damage protection, to prevention of pollution, to protection of land containing shellfish, or to the protection of fisheries" (Reference 8). The town can impose conditions to protect these interests. The commissioner of the Department of Environmental Quality Engineering (DEQE) can also impose conditions, which would supersede those imposed by the town itself.

The commissioner of the DEQE has the authority "to protect inland wetlands and floodplains by establishing encroachment lines for the purpose of preserving and promoting the public safety, private property, wildlife, fisheries, water resources, floodplain areas, and agriculture" (Reference 8). The commissioner may adopt orders regulating, restricting, or prohibiting the altering or polluting of inland wetlands by designating lines upon which no obstruction or encroachment would be permitted without prior approval. These restrictions require notification to each landowner affected, public hearings, and approval by the town.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the community.

The discharges for Gates Brook were determined using a method developed by the U. S. Geological Survey (USGS) specifically for Massachusetts (Reference 9). This methodology takes into consideration both the slope of the main channel and the drainage area. However, because the USGS method does not adequately provide for increased flow rates resulting from urbanization, the flows determined were modified using a second reference, a method also developed by the USGS, for urbanization in Oklahoma (Reference 10). The latter provides for increased flows by taking into consideration the degree of imperviousness of the drainage area and the percentage of area served by storm sewers.

Regional equations developed by the USGS were used to compute discharge-frequency data for the net contributing watersheds of Waushacum and Tributary to Waushacum Brooks (Reference 11). Peak discharges from the upper 5.1 square miles of Waushacum Brook are generally controlled by surcharge storage in East Waushacum and West Waushacum Ponds, according to the Flood Insurance Study for the Town of Sterling (Reference 12). Therefore, peak flows are based on the regional equations applied to the net drainage areas downstream of the two ponds. These equations relate discharge frequencies to basin characteristics and were used to estimate 10-, 50-, and 100-year peak discharges. The 500-year peak discharges were estimated by frequency curve extrapolation.

A summary of the drainage area-peak discharge relationships for the streams studied by detailed methods is shown in Table 1, "Summary of Discharges."

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
GATES BROOK					
At Boston and Maine Railroad	1.9	211	325	384	556
At State Route 140	1.6	191	294	347	503
Above intersection of Worcester Road and Howard Avenue	1.2	159	241	282	404

TABLE 1 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
WAUSHACUM BROOK					
At confluence with Wachusett Reservoir	8.3	235	410	520	[illegible]
Upstream of confluence of Tributary to Waushacum Brook	6.4	95	170	210	[illegible]
TRIBUTARY TO WAUSHACUM BROOK					
At confluence with Waushacum Brook	1.7	140	250	310	[illegible]
Upstream of confluence of unnamed brook	0.2	17	30	40	[illegible]

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

Cross sections for the backwater analysis of Gates Brook were obtained from aerial photographs flown in November 1978 at a scale of 1:1,200 (Reference 13). The below-water sections were obtained by field measurement. All bridges, dams, and culverts were field-checked to obtain elevation data and structural geometry.

The valley portions of the cross section data for Waushacum Brook and Tributary to Waushacum Brook were obtained photogrammetrically by James W. Sewall Co.; the below-water portions were estimated based on surveyed data at structures (Reference 14). Elevation data and structural geometry for all bridges were obtained by field survey.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the Flood Insurance Rate Map (Exhibit 2).

Water-surface elevations of floods of the selected recurrence intervals were computed using the COE HEC-2 step-backwater computer program (Reference 15). Starting water-surface elevations for Gates Brook and Waushacum Brook were calculated using the slope/area method. For Tributary to Waushacum Brook, the 10-year return water-surface elevation at the confluence of Waushacum Brook was used as the starting water-surface elevation. Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals.

In those areas where the analysis indicated supercritical flow conditions, critical depth was assumed for the flood elevation because of the inherent instability of supercritical flow.

Channel roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and were based on field observations of the river and floodplain area. Channel "n" values for Gates Brook ranged from 0.030 to 0.045, and the overbank "n" values ranged from 0.060 to 0.100. For Waushacum Brook and Tributary to Waushacum Brook, the channel "n" value was 0.030, and the overbank "n" values ranged from 0.020 to 0.100.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps; the descriptions of the marks are presented in Elevation Reference Marks (Exhibit 3).

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each Flood Insurance Study provides 100-year flood elevations and delineations of the 100- and 500-year floodplain boundaries and 100-year floodway to assist in developing floodplain management measures.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For the streams studied in detail, the 100- and 500-year floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, for Gates Brook, the boundaries were interpolated using topographic maps at a scale of 1:2,400 with a contour interval of 5 feet (Reference 16). For Waushacum Brook and Tributary to Waushacum Brook, boundaries between cross sections were interpolated using topographic maps at a scale of 1:4,800 with a contour interval of 5 feet (Reference 17).

For the flooding sources studied by approximate methods, the 100-year floodplain boundaries were delineated using the previous Flood Insurance Study for the Town of West Boylston (Reference 18).

The 100- and 500-year floodplain boundaries are shown on the Flood Insurance Rate Map (Exhibit 2). On this map, the 100-year floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A and AE), and the 500-year floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 100- and 500-year floodplain boundaries are close together, only the 100-year floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 100-year floodplain boundary is shown on the Flood Insurance Rate Map (Exhibit 2).

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 100-year floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as a minimum standard that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (Table 2). The computed floodways are shown on the Flood Insurance Rate Map (Exhibit 2). In cases where the floodway and 100-year floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

The area between the floodway and 100-year floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 2.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Waushacum Brook								
A	150[1]	20	64	8.1	392.9	392.9	393.0	0.1
B	670[1]	20	55	9.5	402.0	402.0	402.0	0.0
C	815[1]	9	53	9.8	408.7	408.7	408.7	0.0
D	1,415[1]	18	65	8.0	418.3	418.3	418.8	0.5
E	1,875[1]	17	82	6.3	421.6	421.6	422.6	1.0
F	2,040[1]	15	56	9.4	424.5	424.5	424.5	0.0
G	2,660[1]	113	376	1.4	426.4	426.4	427.3	0.9
H	3,210[1]	337	1,058	0.2	426.5	426.5	427.3	0.8
I	3,810[1]	381	658	0.3	426.5	426.5	427.5	1.0
J	4,480[1]	142	249	0.8	426.5	426.5	427.5	1.0
K	4,980[1]	9	25	8.4	427.5	427.5	427.6	0.1
L	5,120[1]	20	114	1.8	430.7	430.7	430.7	0.0
Tributary to Waushacum Brook								
A	530[2]	313	584	0.5	426.4	426.4	427.2	0.8
B	1,130[2]	185	209	1.5	426.8	426.8	427.4	0.6
C	1,372[2]	200	1,204	1.7	431.5	431.5	431.6	0.1
D	1,922[2]	150	848	1.7	431.5	431.5	431.7	0.2
E	2,462[2]	102	546	1.3	431.5	431.5	431.7	0.2
F	3,092[2]	12	19	0.6	431.5	431.5	431.7	0.2
G	3,330[2]	5	8	5.1	455.3	455.3	455.9	0.6

[1]Feet above confluence with Wachusett Reservoir

[2]Feet above confluence with Waushacum Brook

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WEST BOYLSTON, MA

(WORCESTER CO.)

FLOODWAY DATA

WAUSHACUM BROOK AND TRIBUTARY TO WAUSHACUM BROOK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Gates Brook								
A	0.0205	25	221	1.7	452.8	452.8	452.8	0.0
B	0.1035	25	56	6.9	452.8	452.8	453.0	0.2
C	0.1245	20	45	8.6	460.5	460.5	460.5	0.0
D	0.2075	20	52	7.4	468.4	468.4	468.4	0.0
E	0.2885	15	46	7.5	480.3	480.3	480.3	0.0
F	0.3155	20	128	2.7	484.4	484.4	484.4	0.0
G	0.3755	30	59	5.9	485.4	485.4	485.4	0.0
H	0.4195	20	62	5.6	486.7	486.7	487.5	0.8
I	0.4515	20	118	3.0	495.7	495.7	495.7	0.0
J	0.4985	20	80	4.3	495.7	495.7	496.1	0.4
K	0.6305	40	131	2.2	506.1	506.1	506.3	0.2
L	0.6705	60	77	3.7	506.8	506.8	506.9	0.1
M	0.7235	60	160	1.8	508.0	508.0	508.6	0.6
N	0.7455	30	62	4.5	509.1	509.1	509.1	0.0
O	0.8085	20	44	6.5	512.4	512.4	512.6	0.2
P	0.8345	20	103	2.7	516.8	516.8	516.8	0.0
Q	0.8955	20	41	6.9	521.8	521.8	521.9	0.1
R	0.9235	20	120	2.3	535.0	535.0	535.0	0.0
S	1.0145	20	40	7.1	539.4	539.4	539.4	0.0

[1]Miles from Boston and Maine Railroad

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WEST BOYLSTON, MA
(WORCESTER CO.)

FLOODWAY DATA

GATES BROOK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Gates Brook (continued)								
T	1.0345	20	49	5.8	554.3	554.3	554.3	0.0
U	1 1045	30	83	3.4	556.1	556.1	557.1	1.0
V	1.1295	20	136	2.1	574.6	574.6	574.6	0.0

[1]Miles from Boston and Maine Railroad

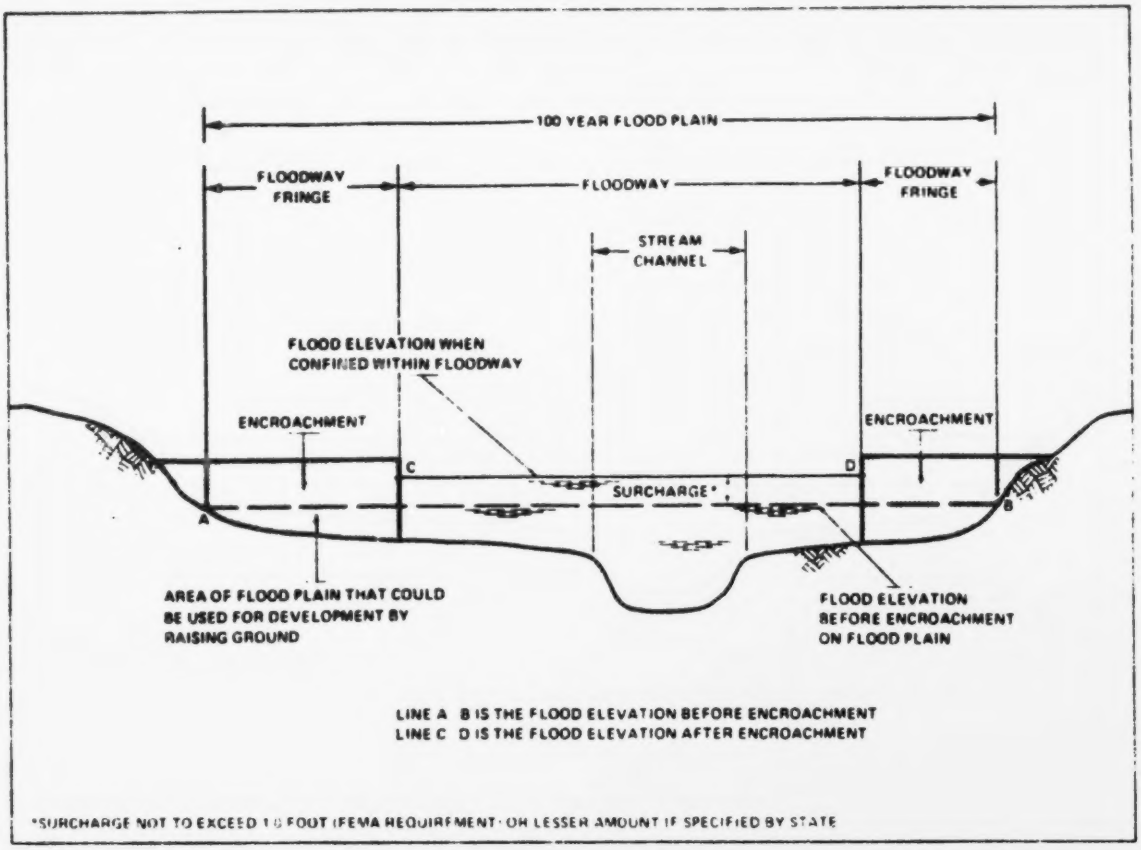
TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WEST BOYLSTON, MA
(WORCESTER CO.)

FLOODWAY DATA

GATES BROOK


100 YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE A B IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE C D IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE

FLOODWAY SCHEMATIC Figure 2

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. The zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by detailed methods. In most instances, whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-depths derived from the detailed hydraulic analyses are shown within this zone.

Zone A99

Zone A99 is the flood insurance rate zone that corresponds to areas of the 100-year floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or depths are shown within this zone.

Zone V

Zone V is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no base flood elevations are shown within this zone.

Zone VE

Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, and to areas of 100-year flooding where average depths are less than 1 foot, areas of 100-year flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

Zone D

Zone D is the flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

6.0 FLOOD INSURANCE RATE MAP

The Flood Insurance Rate Map is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 100-year floodplains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 100- and 500-year floodplains. Floodways and the locations of selected cross sections used in the hydraulic analyses and floodway computations are shown where applicable.

7.0 OTHER STUDIES

Flood Insurance Studies have been prepared for the City of Worcester and the Towns of Boylston, Holden, Princeton, and Sterling (References 19, 20, 21, 22, and 12). The results of this study are in exact agreement with the results of those studies.

Due to its more up-to-date nature, this study supersedes the previously published Flood Insurance Study for the Town of West Boylston (Reference 18).

8.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting FEMA, the Natural and Technological Hazards Division, J. W. McCormack Post Office and Courthouse Building, Room 462, Boston, Massachusetts 02109.

9.0 BIBLIOGRAPHY AND REFERENCES

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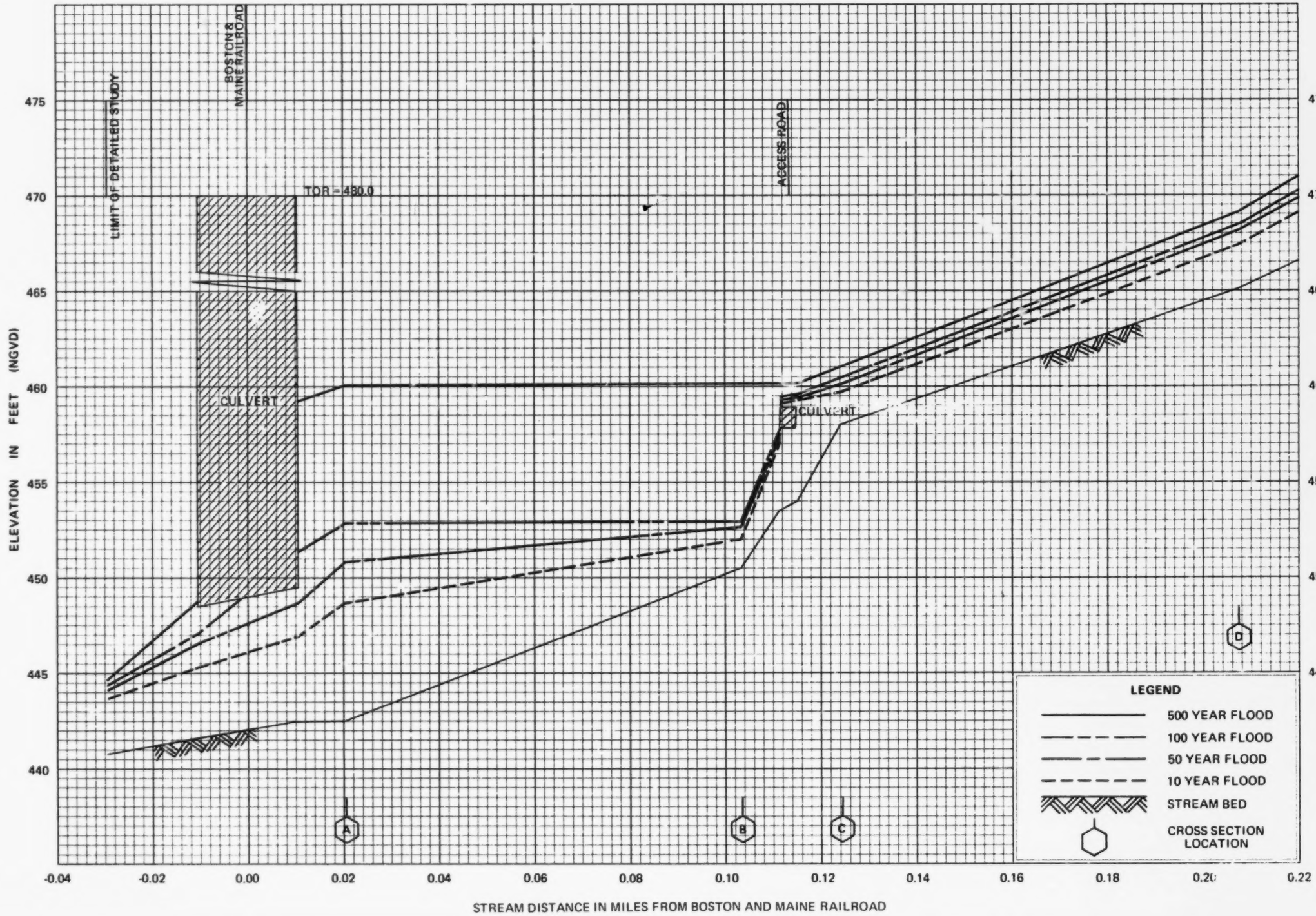
EXHIBIT 3 - ELEVATION REFERENCE MARKS

Reference Mark	FIRM Panel	Elevation (Feet NGVD)	Description of Location
RM 1	05	568.99	Point on southwest corner of concrete headwall on downstream side of Gates Brook culvert at Pierce Street.
RM 2	05	499.98	Point on southwest corner of concrete headwall on downstream side of Gates Brook culvert at Worcester Street at Fair Shopping Center.
RM 3	05	486.32	Point on northwest corner of concrete headwall on downstream side of Gates Brook culvert at State Route 140.
RM 4	05	495.10	USC&GS and State Survey disk M12H set in concrete monument flush with ground, located in triangular grass plot at intersection of State Route 12 and Worcester Street, south of Congregational Church, approximately 12.5 feet north of south curb of grass plot and approximately 14 feet west of east curb, approximately 2 feet south of pole 87 and approximately 4.1 feet north of iron post sign for Worcester County Sanitarium.
RM 5	06	423.303	Chiseled square on boulder on north bank of Waushacum Brook, approximately 266 feet east along rail of intersection of Prescott Street and Boston and Maine Railroad and approximately 40 feet south of southern rail.



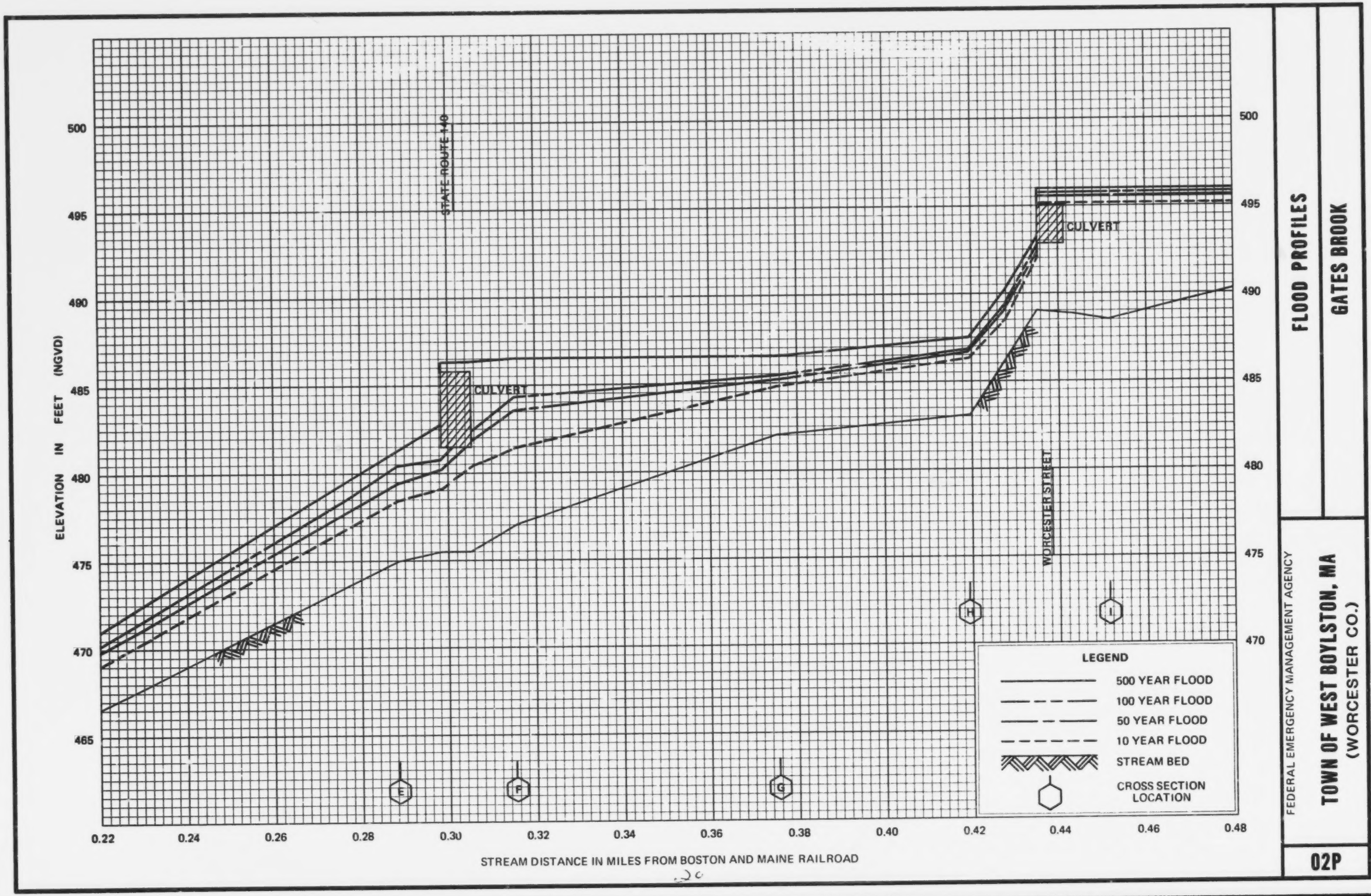
FLOOD PROFILES

GATES BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WEST BOYLSTON, MA
(WORCESTER CO.)

01P



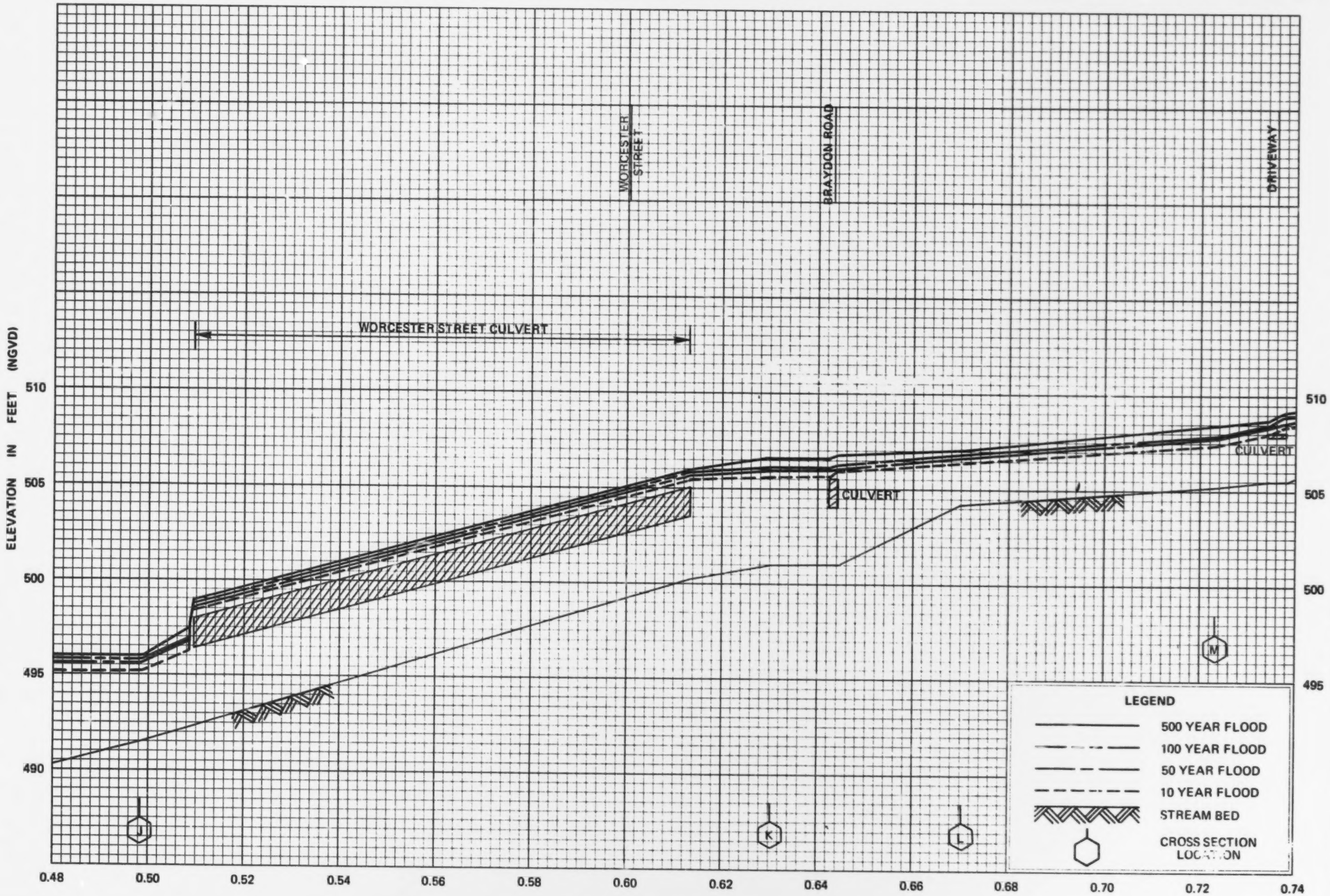
FLOOD PROFILES

GATES BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WEST BOYLSTON, MA
(WORCESTER CO.)

02P



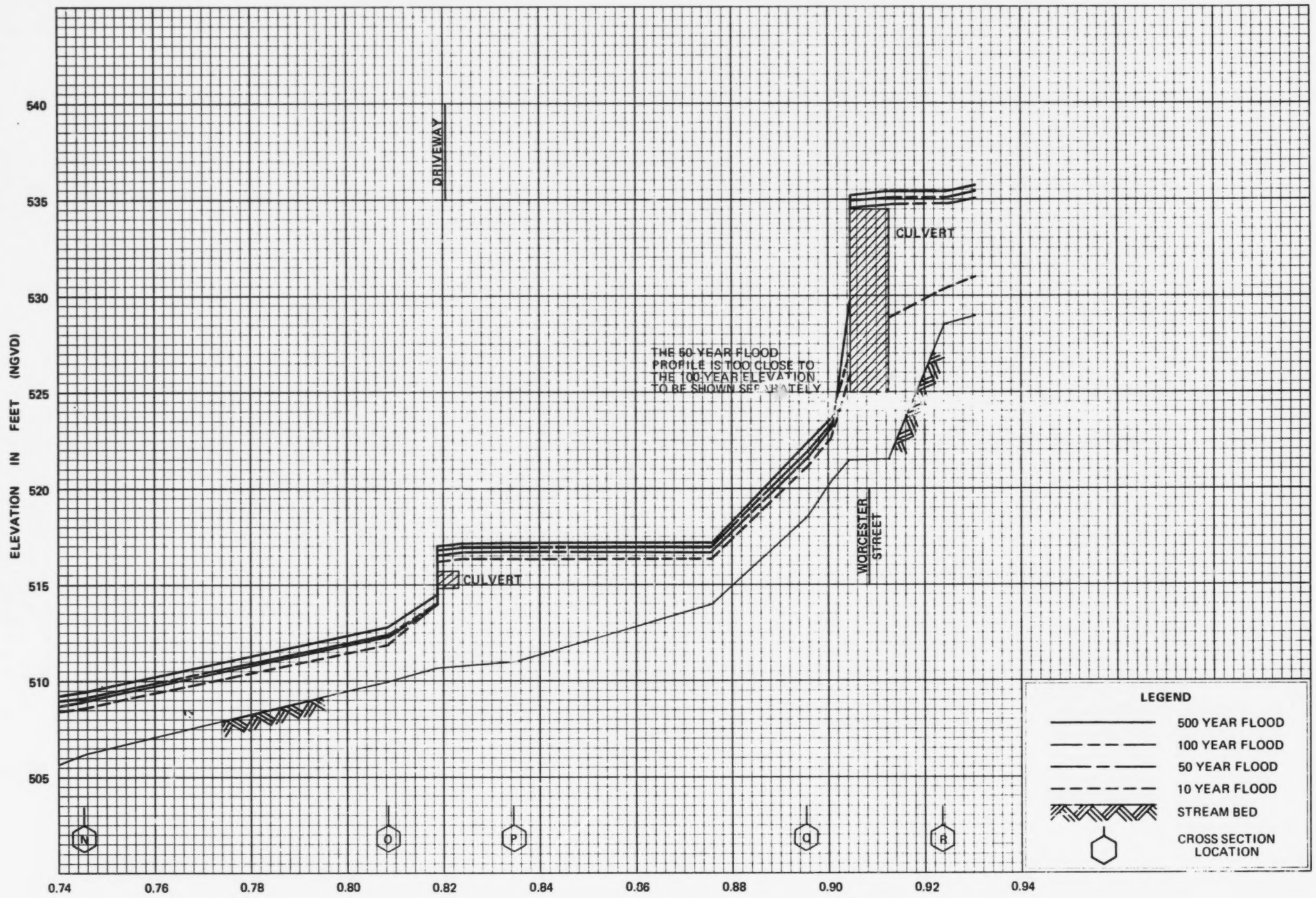
FLOOD PROFILES

GATES BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WEST BOYLSTON, MA
(WORCESTER CO.)

03P



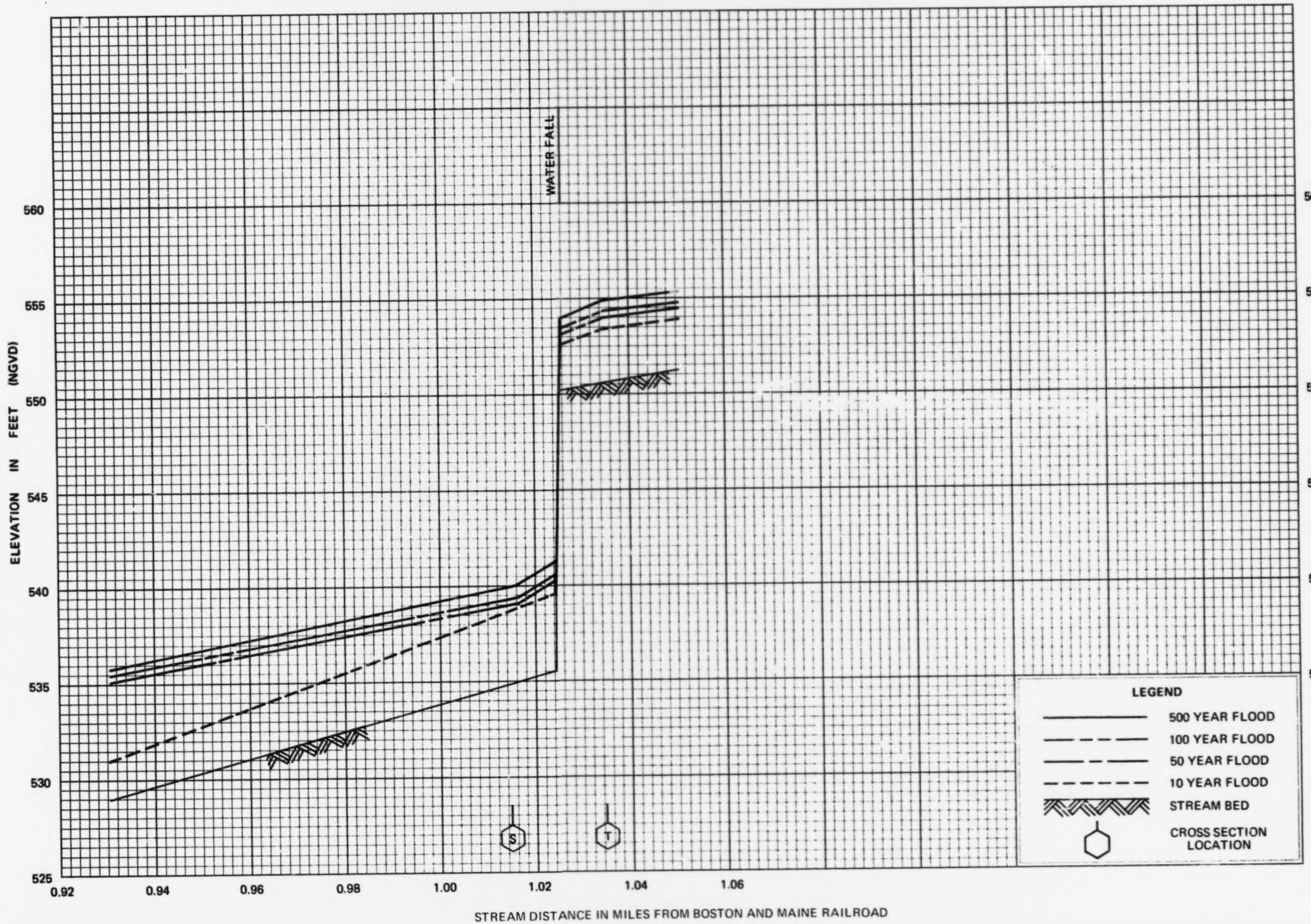
FLOOD PROFILES

GATES BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WEST BOYLSTON, MA
(WORCESTER CO.)

04P



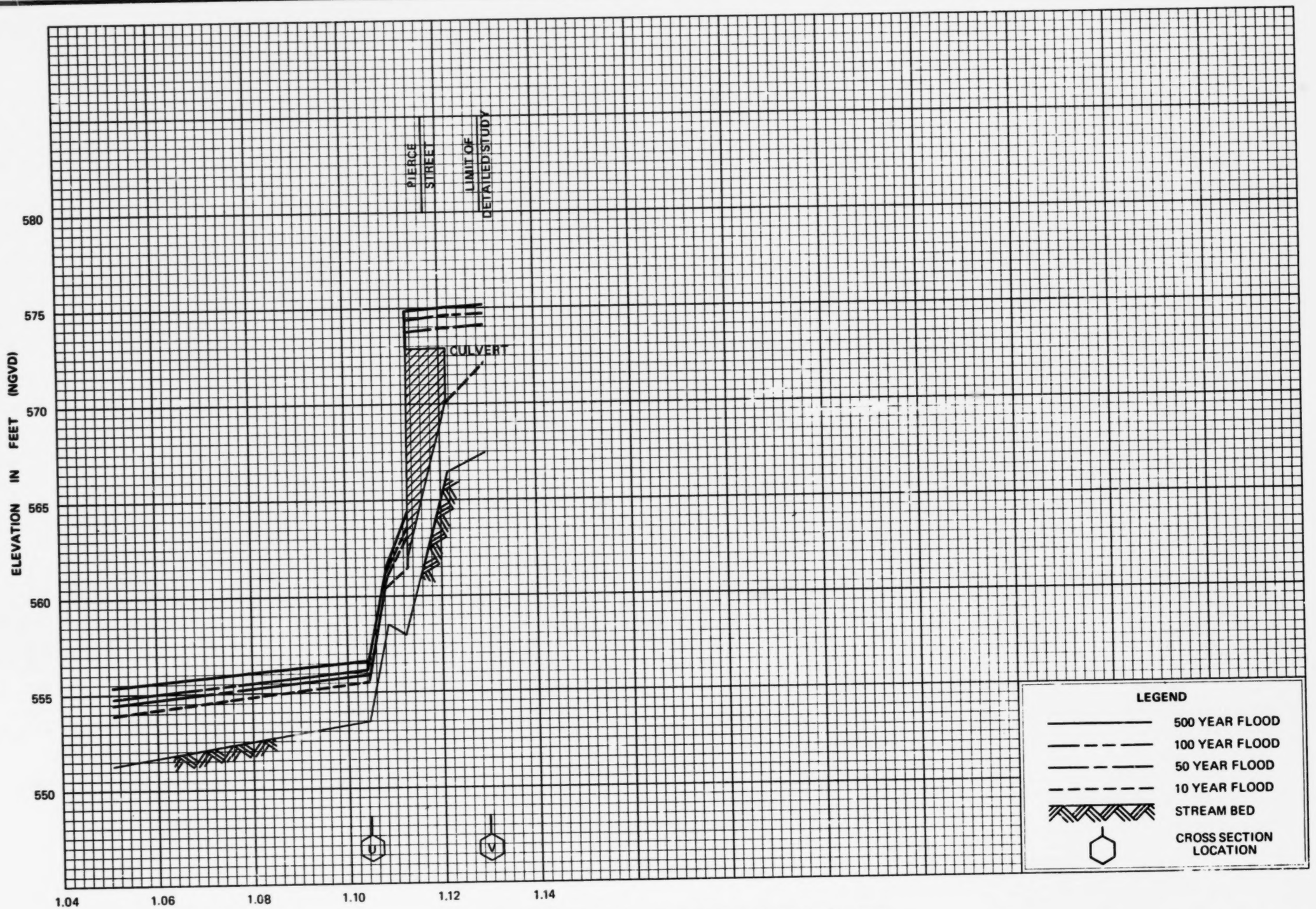
FLOOD PROFILES

GATES BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WEST BOYLSTON, MA
(WORCESTER CO.)

05P



FLOOD PROFILES

GATES BROOK

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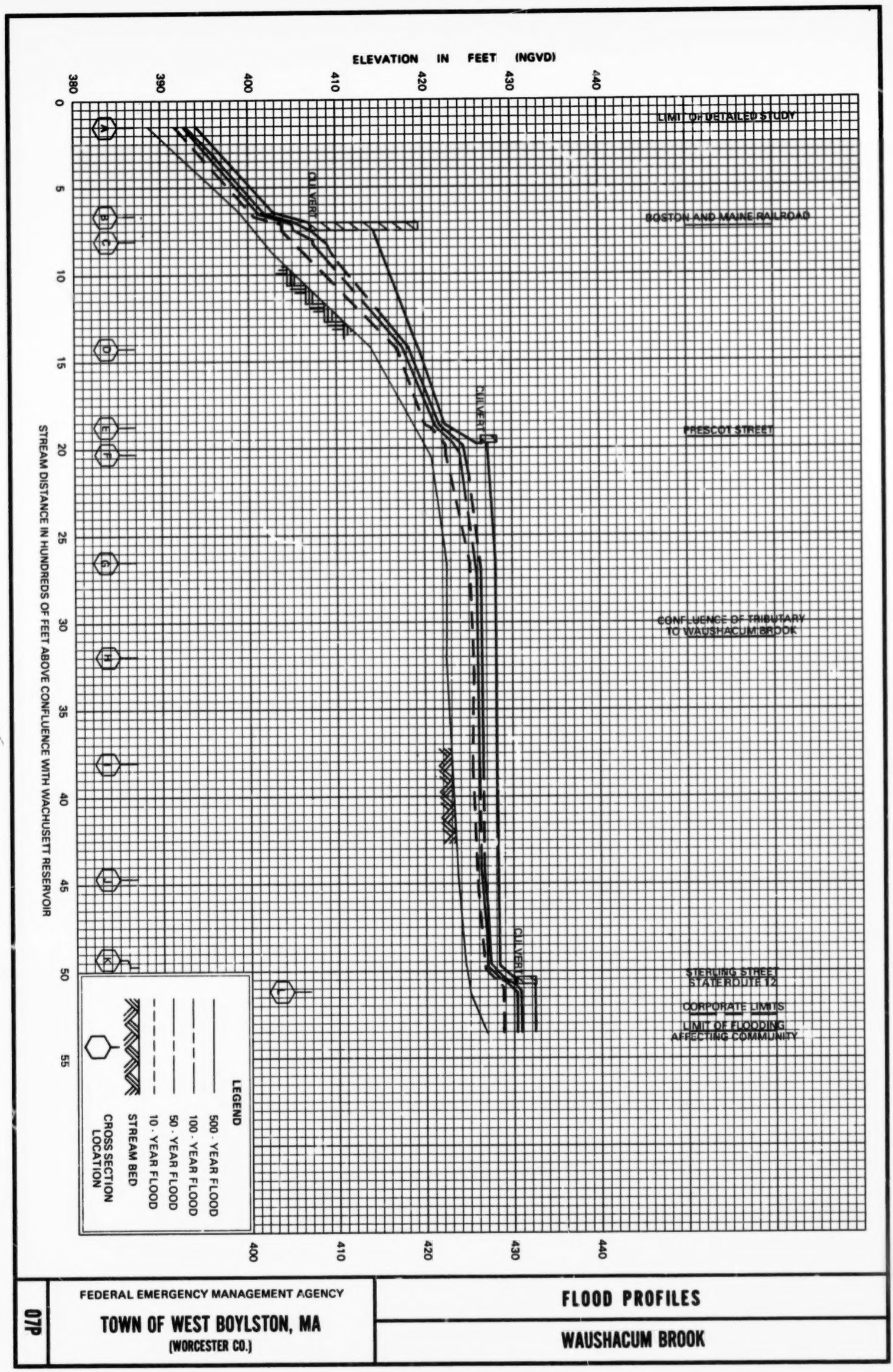
TOWN OF WEST BOYLSTON, MA
(WORCESTER CO.)

06P



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07P

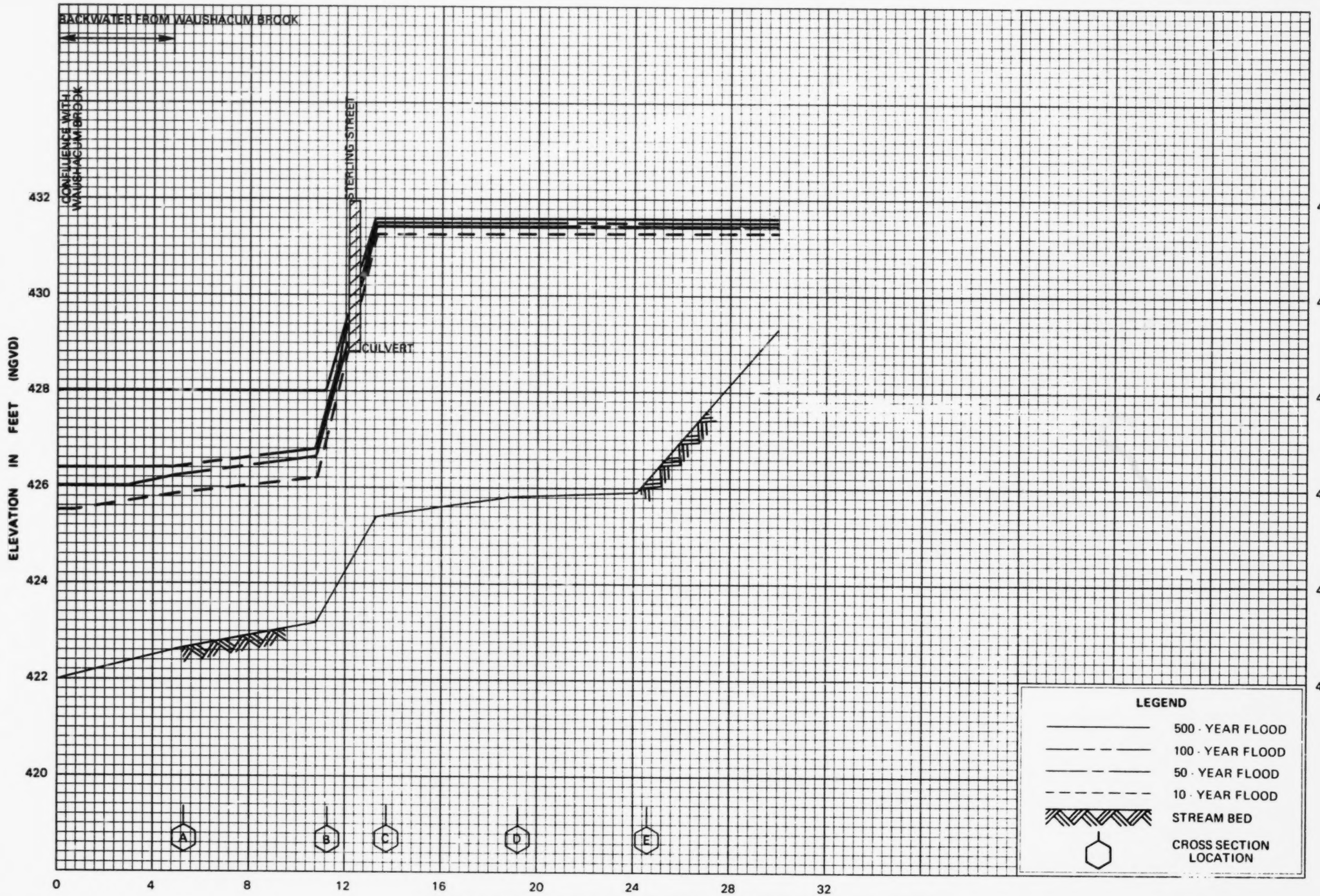
FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WEST BOYLSTON, MA

(WORCESTER CO.)

FLOOD PROFILES

WAUSHACUM BROOK



FLOOD PROFILES

TRIBUTARY TO WAUSHACUM BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WEST BOYLSTON, MA
(WORCESTER CO.)

08P

ELEVATION IN FEET (NGVD)

460
455
450
445
440
435
430
425

THE 50 AND 500-YEAR FLOOD PROFILES ARE TOO CLOSE TO THE 100-YEAR ELEVATION TO BE SHOWN SEPARATELY.

LIMIT OF DETAILED STUDY

F

G

30.0 30.5 31.0 31.5 32.0 32.5 33.0 33.5

STREAM DISTANCE IN HUNDREDS OF FEET ABOVE CONFLUENCE WITH WAUSHACUM BROOK

LEGEND

- 500 - YEAR FLOOD
- 100 - YEAR FLOOD
- 50 - YEAR FLOOD
- 10 - YEAR FLOOD
- STREAM BED
- CROSS SECTION LOCATION

FLOOD PROFILES

TRIBUTARY TO WAUSHACUM BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF WEST BOYLSTON, MA
(WORCESTER CO.)

09P